Meteor 55: 3rd Weekly Report (28.10.2002-3.11.2002)

It continues to be hard to report succintly on Meteor 55 due to the diversity of measurement programs going on. The third week of the cruise passed quickly and several exciting results are starting to emerge. The intense cross-discipline discussion continues at coffee breaks and at the lunch table. Presently plans are being hatched, during informal discussions, for a set of mega-experiments to be conducted during the long final transit to Cameroon. It looks like this 'grand-finale' may end up involving almost all of the biological and chemical groups on board.

The week started with a transit towards the equator along 26° 30'W. This transit had been planned to allow the atmospheric chemists to sample across the Intertropical Convergence Zone (ITCZ), and this worked out perfectly. The crossing of the ITCZ was seen very clearly in the atmospheric pCO_2 data (the strong seasonality of northern hemisphere pCO_2 causes northern hemisphere air to have a slightly lower pCO_2 than southern hemisphere air at this time of year). The gradient between the hemispheres was also exceptionally well resolved in several trace gases, with acetone and methanol being higher in the northern hemisphere air and dimethyl sulphide being higher south of the ITCZ. At the time and location of our transit, the gradients were quite sharp, being concentrated into a band between 7°N and 5°N.

The southward transit also allowed us to sample higher surface biomass, visible in Seawifs imagery, lying within 1 degree north and south of the equator. We arrived at the equator early on the morning of 29 October, just in time for the morning productivity station. In total 4 stations were occupied at the equator between 26°W and 23.5°W. At these stations we found significantly deeper mixed layers (up to 80m deep) and, associated with this, higher near-surface bromoform levels and lower methyl iodide concentrations. On the morning of 30 October we arrived at the location of a University of Bremen long-term sediment trap mooring. It took less than 2 hours to release the mooring and get it on deck, which is testimony to the efficiency and great skill of the Meteor's deck crew.

Following the brief stay at the equator we returned northwards along 24°W in order to resume our main west-east transect. Much of this time we lay under a dense swath of cloud and we were able to sample occasionally intense tropical rainstorms. The remainder of the section work will be conducted next week. We have planned an ambitious series of stations along a transit into the coastal waters of Guinea Bissau. One goal is to examine trace-gas production in the productive waters off the west coast of Africa and to see whether we can detect an influence of coastal upwelling, or upwelling associated with the Guinea Dome, on surface water gas saturations, air-sea fluxes and atmospheric concentrations.

In addition to measurements and experiments we have been busy taking lots of photos. Some of these have been compiled into photo-essays designed to give younger schoolchilden an impression of who we are and what we are doing. These should be accessible at: www.meeresforschungonline.de

And now, as promised last week, here are reports from the various trace gas measurement groups on board:

- Brominated Halocarbons. The ocean is a source for a wide variety of naturally occurring volatile halogenated compounds. Of particular significance is the sea-to-air flux of bromoform ($CHBr_3$) which significant for ozone destruction reactions. The strong atmospheric convection typical of

tropical regions provides a mechanism for rapid transport of short-lived gases from the ocean surface to the upper troposphere and lower stratosphere. We are therefore characterizing the sea-to-air flux of bromoform and related compounds along the Meteor 55 cruise track. Preliminary results, from mass spectrometry based measurements, show peak levels of bromoform close to the sub-surface chlorophyll maximum and a strong gradient towards the surface. Below the chlorophyll max, levels decrease with depth and concentrations of other compounds that are degradation products of bromoform, increase. We are therefore also investigating whether this bromoform degradation pathway has potential for use as a circulation tracer over timescales of many decades to hundreds of years.

- Alkyl nitrates: Another family of trace gases being measured on board are the light alkyl nitrates. Methyl and ethyl nitrate have recently been found to be emitted from the ocean in certain regions - a result that was surprising as these gases had been assumed to be present in the atmosphere mainly as a result of anthropogenic activities. The alkyl nitrates influence the ability of the atmosphere to cleanse itself of pollutants and other chemical species. The discovery of an oceanic source for these species has therefore opened up many questions. Vertical profiles of these compounds are being measured in order to shed light on the (unknown) processes responsible for production of these gases. In addition, surface underway samples and air samples are being collected and analysed to calculate the fluxes of these compounds in and out of the ocean.

- Methyl Iodide. Methyl iodide (CH_3I) is responsible for carrying a large flux of iodine from the ocean to the atmosphere, where the CH_3I is rapidly broken down. The iodine subsequently participates in a range of potentially important atmospheric processes. A regular program of measurements for CH_3I in surface water and air has been conducted along the cruise track. Separate measurements of depth profiles are being made in conjunction with the alkyl nitrate determinations. The CH_3I has been strongly supersaturated throughout the cruise, and some clear spatial variations have been observed, particularly close to the equator. In the past week, a series of incubation experiments has been initiated to investigate factors responsible for the high supersaturation of CH_3I in surface seawater. In particular we want to determine whether there is any direct biogenic formation of this compound, or whether photochemical processes are primarily responsible. Initial results from the very first of these experiments this week look promising, and if repeatable, may shed considerable light on the formation of this gas.

- DMS and DMSP. A set of simulated in situ experiments are being conducted on board to estimate the production and turnover of dissolved and cellular dimethylsulphoniopropionate (DMSP) and its response to enrichments of dissolved organic and inorganic nutrients. DMSP is generated in large amounts by phytoplankton and, as the precursor of dimethyl sulphide (DMS), it is the major biogenic source for the volatile reactive sulphur emitted from the ocean. Incubation experiments have been conducted on deck in large-volume containers. We have also conducted a set of experiments to determine the variability of the bacterial degradation of dissolved DMSP in response to selective nutrient enrichments. In the first results available, we detected a strong response of DMSP degradation to enrichment with dissolved organic nutrients but relatively low response to enrichment with dissolved inorganic nutrients in both the equatorial upwelling as well as in oligotrophic waters.

- N_2O. Nitrous oxide (N_2O) is an atmospheric trace gas which, directly (as a greenhouse gas) and indirectly (as precursor for radicals involved in stratospheric ozone depletion), influences climate. Preliminary measurements in the atmosphere and surface ocean reveal surface concentrations that

are close to equilibrium value indicating that oligotrophic tropical Atlantic is a weak source of N_2O for the atmosphere. We have also measured a number of vertical profiles which show that N_2O is supersaturated throughout the sub-surface water column including a considerable accumulation below the euphotic zone with maximum values at about 400m. As we have progressed from west to east we have seen increasing maximum N_2O concentrations which are inversely correlated with the dissolved oxygen concentration in the oxygen minimum zone.

- CO_2. Measurements of the CO_2 partial pressure of surface seawater and air are being made continuously during the M55 cruise. So far, most measurements have documented conditions typical for tropical oceans with surface waters being close to equilibrium with the atmosphere. Strong deviations from equilibrium have also been measured however. Significant undersaturation was found within a large region affected by the Amazon river plume. The undersaturation likely documented the biogeochemical aftermath of an earlier phase of high productivity. The observed pattern gave rise to a sizable sink for atmospheric CO_2. Significant supersaturation was observed at the equator representing the effects of equatorial upwelling. Due to the sluggish exchange of CO_2 between ocean and atmosphere, measurements of the CO_2 partial pressure likely provide a long-term surface 'memory' of prior upwelling.

Next week we will have reports from the biology and trace metal programs as well as more atmospheric chemistry programs.

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